

**INVESTIGATIONS OF TREE FOLIAGE
CONTAMINATION IN THE VICINITY OF
TORONTO REFINERS AND SMELTERS
LTD., TORONTO, 1989 AND 1990**

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Abstract

Samples of tree foliage around the former Toronto Refiners and Smelter (TRS) operation were collected in the early fall of 1989 and 1990, and analyzed for lead and other metals associated with this lead processing facility. Environmental lead concentrations were dramatically lower than they were in 1987 and previously, reflecting the closure of TRS and the cessation of lead emissions. A review of air quality data confirmed that ambient air concentrations of lead were in the range of background levels encountered in control locations away from industrial lead point sources. Despite the general decline of foliar lead concentrations near TRS, there remained some sites where the concentrations were still marginally elevated. These sites were along the railway embankment south of TRS property. Soil collected at these sites in 1987 contained as much as 9% lead. The marginal foliar contamination was, therefore, attributed to root uptake from this severely contaminated soil. Cadmium uptake was also evident at one of these sites.

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1 INTRODUCTION

1.1 Toronto Refiners and Smelters

Toronto Refiners and Smelters Limited (TRS) operated a secondary lead refining facility at 28 Bathurst Street in Toronto, Ontario for several decades. The primary function of the facility was to recover the lead from products such as used lead-acid batteries.

TRS no longer operates at this location. The property was expropriated by the City of Toronto in July, 1988, and vacated by TRS in February, 1989. There was no activity on the property until early 1992 when the demolition of structures, followed by the excavation of contaminated soil, was initiated.

1.2 Environmental Monitoring and Remediation

During the time that TRS operated at this property, lead and lead alloys were released into the surrounding community. Monitoring of ambient air concentrations of lead has been and is currently conducted by the Ministry of the Environment, Central Region Abatement West office. That office maintains a network of suspended particulate and dustfall monitors in the vicinity of TRS. The material collected by these monitors is analyzed for lead.

Since 1972, the Phytotoxicology Section, Air Resources Branch, has conducted annual (except 1988) collections of tree foliage. These foliar samples were analyzed for lead and other metals. Other Phytotoxicology investigations have included soil collection and analyses and the use of moss bags (*Sphagnum* moss in nylon mesh bags) as passive accumulators of airborne metals. The most recent report on Phytotoxicology Section investigations near the TRS facility discussed data from 1986 and 1987 (Ref. 1).

Because of evidence of significant contamination of soil, allegedly caused by emissions from TRS, as well as other urban sources, a large-scale soil replacement project was undertaken on residential and publicly-accessible properties in two phases; October and November, 1988, and May through August, 1989. The properties designated for soil replacement extended as far as 300 metres to the west, north and east from TRS (Ref. 2).

2 PHYTOTOXICOLOGY INVESTIGATIONS, 1989 AND 1990

This report will present and discuss the results of Phytotoxicology Section investigations conducted in 1989 and 1990. Because TRS was no longer operating and the property was in the possession of the City of Toronto, these investigations can be described as post-operational.

2.1 TRS Tree Foliage Survey Design

Foliage from eleven sample trees located within 350 metres of TRS were sampled in the month of September of 1989 and 1990.

These trees had been sampled annually since at least 1980 (except 1988). Some were sampled prior to 1980. The locations of these trees is displayed in Figure 1.

All sample trees were *Ailanthus altissima* (Tree-of-Heaven). Most of the trees sampled in 1989 and 1990 were the same trees sampled since 1981. Two established sample trees were lost after the 1987 collection and alternatives were sampled in 1989 and 1990. These replacements were very close to the original location. This consistency permits development of temporal trends in foliar contamination by lead.

2.2 Sample Collection, Processing and Analysis

Sample collection consisted of cutting branches from the sides of trees facing the TRS property with pruning poles, removing the foliage and placing this foliage into polyethylene bags along with sample number tags. Duplicate samples from each tree were collected in 1989 and 1990.

Sample processing involved oven-drying of the foliage, removal of any non-foliage material (fruit, twigs) and grinding the sample in a rotating, stainless steel blade (Wiley™) mill to pass through a one millimetre screen.

Processed samples were submitted to the MOE Laboratory Services Branch and analyzed for lead, antimony, arsenic and cadmium using standard, documented analytical procedures.

2.3 Gerrard Street Control Area Survey

The Gerrard Street Control Area (GSCA) is an area bounded by Gerrard Street East, the CNR railway line, King Street East and the Don Valley Parkway. Within the GSCA are ten locations containing Norway maple and *Ailanthus* trees. Foliage samples collected from these trees are used to compare the concentrations of lead with those in tree foliage collected near a point source such as TRS. Since there are no point sources in the GSCA, lead contamination is attributable to general urban sources, specifically lead from the combustion of gasoline.

Sampling in the GSCA likewise was conducted in September of 1989 and 1990 using procedures employed in the TRS collections. Because all TRS trees were *Ailanthus*, only *Ailanthus* tree data from the GSCA are considered in this report.

3 AIR QUALITY MONITORING

As previously mentioned, The MOE Central Region maintains a network of air quality monitors. These monitors consist of suspended particulate (HiVol) samplers and dustfall jars. In some cases, the two types of monitors are co-located. Lead concentrations are determined in the daily suspended particulate and monthly dustfall samples.

Only one suspended particulate sampler has operated continuously between 1981 and 1990. It is designated Station 31085. A second sampler, Station 31181, operated between 1983 and 1989. Locations of these stations are indicated in Figure 1. The GSCA has had an identical collector, Station 31082, in continuous operation.

Between 1981 and 1990, there have been ten locations in the TRS area where lead in dustfall was determined. However, two of these were discontinued in 1987 or 1988, while two others only operated in the mid-to-late 1980s. The remaining six locations are indicated in Figure 1. The GSCA has had a continuously-operating lead in dustfall collector co-located with the suspended particulate sampler.

4 RESULTS OF TREE FOLIAGE CONTAMINANT SURVEY

4.1 Lead in Tree Foliage

Table 1 summarizes the concentrations of lead encountered in tree foliage collected in 1989 and 1990 in the vicinity of TRS. The reported concentrations are means of the duplicate samples. This table also contains the data from the 1981 through 1987 collections reported in the previous Phytotoxicology Section report on TRS investigations (Ref. 1). (There were no collections in 1988.) Also given are the mean lead concentrations in Ailanthus foliage from the GSCA.

Table 1: Lead Concentrations (ug/g, dry weight) in Ailanthus Foliage near TRS and in the GSCA 1981 to 1990										
Site No.	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
10	17	16	25	22	48	20	16	NR	5.2	3.9
4	30	24	27	26	30	26	15	NR	5.1	3.5
51	36	50	<u>160</u>	<u>400</u>	<u>160</u>	<u>105</u>	<u>100</u>	NR	16	4.8
1	<u>310</u>	<u>81</u>	<u>727</u>	<u>240</u>	<u>410</u>	<u>185</u>	<u>165</u>	NR	20	10
50	<u>126</u>	<u>81</u>	<u>95</u>	<u>190</u>	<u>1050</u>	<u>230</u>	<u>170</u>	NR	25	55
43	<u>115</u>	44	<u>163</u>	<u>98</u>	<u>410</u>	<u>275</u>	<u>370</u>	NR	11	20
36	<u>149</u>	<u>113</u>	<u>85</u>	<u>140</u>	<u>185</u>	<u>235</u>	<u>150</u>	NR	15	29
30	43	<u>74</u>	<u>91</u>	<u>63</u>	<u>410</u>	NR	<u>150</u>	NR	3.7	1.7
29	<u>413</u>	<u>131</u>	<u>273</u>	<u>250</u>	<u>140</u>	<u>175</u>	<u>205</u>	NR	4.8	8.5
8	54	33	<u>70</u>	56	<u>82</u>	26	36	NR	4.4	2.2
24	17	16	23	29	40	20	17	NR	2.7	3.1
Mean	119	60	158	138	270	130	127	NC	10	13
GSCA	18	15	20	16	20	8	9.5	NR	5.8	4.1
NR = No Results NC = Not Calculated Underlined data exceed the urban ULN of 60 ug/g (see Appendix)										

4.2 Antimony, Arsenic and Cadmium in Tree Foliage

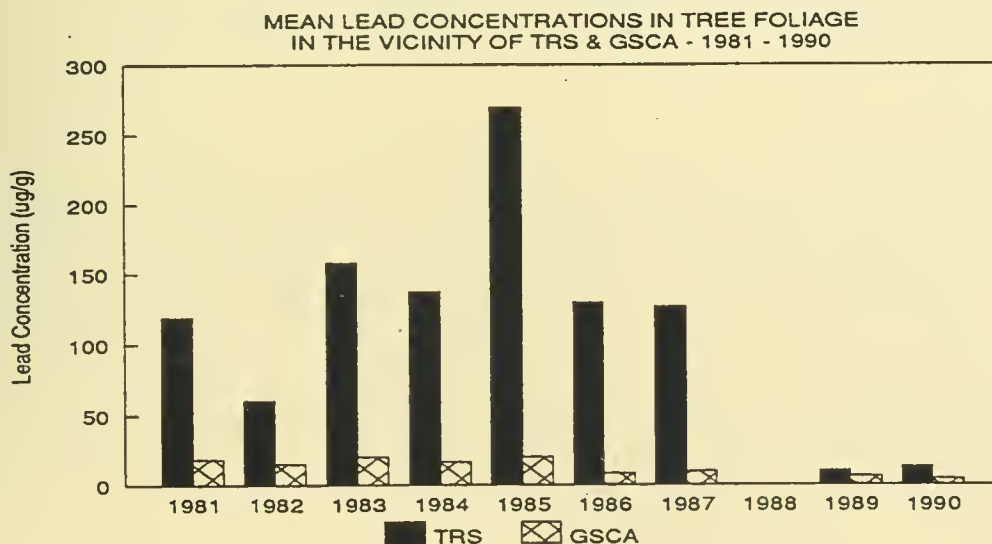
All tree foliage samples from the TRS area collected in 1989 and 1990 were analyzed for antimony (Sb), arsenic (As) and cadmium (Cd) because these elements are suspected of being associated with the lead that was emitted by TRS. Virtually all of these samples had less than: 0.5 ug/g Cd, 1.0 ug/g As and 1.0 ug/g Sb. These data had laboratory qualifications appended indicating concentrations below limits of detection or accurate quantification. The sole exception was Ailanthus foliage from Site 36. The (mean) Cd concentrations were 0.96 and 1.95 ug/g in 1989 and 1990, respectively.

5 LEAD IN FOLIAGE TRENDS NEAR TRS AND IN THE GSCA

The mean concentrations of lead in tree foliage from 1981 through 1990 at sites around TRS and in the GSCA are graphically presented in Figure 2. It is clear that lead concentrations declined dramatically in 1989 and 1990 from those present in 1981 through 1987. This can be attributed directly to the closure of the TRS operation.

This figure also shows notably lower lead in foliage concentrations in the GSCA in 1989 and 1990 compared to concentrations encountered in the early-to-mid 1980s. The phase-out of lead in gasoline is the prime candidate for this response.

FIGURE 2:

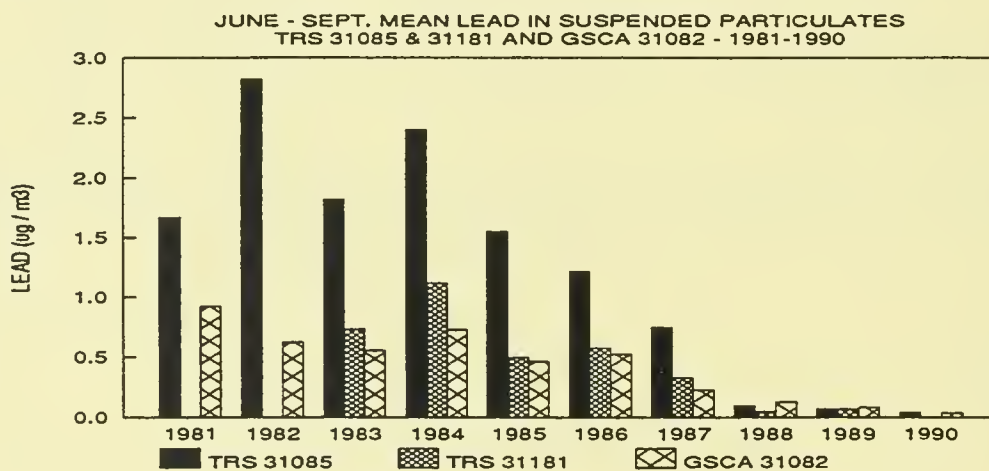


6 LEAD IN SUSPENDED PARTICULATES AND DUSTFALL

Data for lead in suspended particulates and dustfall were obtained from the Air Quality Information System (AQUIS) database. These data provide a means for validating trends observed in foliage contamination.

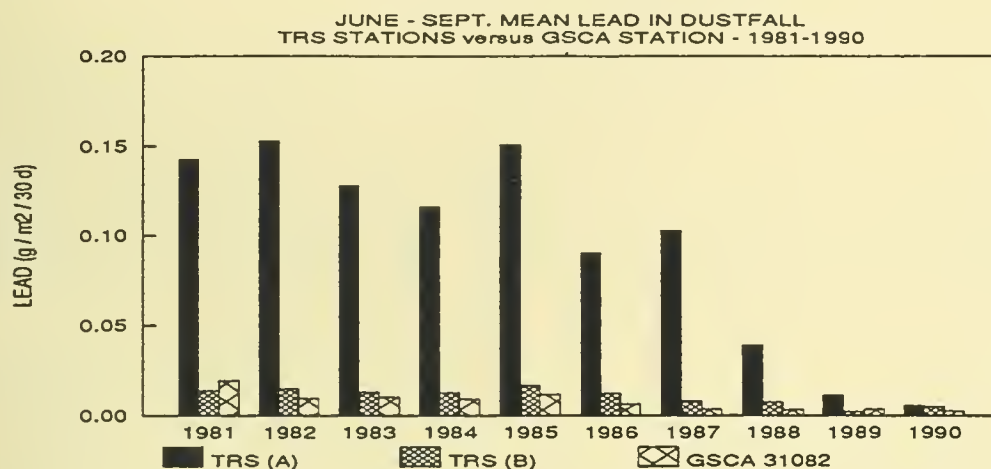
The arithmetic mean of lead in suspended particulates for daily samples from the four summer months of June through September in each year are graphically represented in Figure 3. The summer months were chosen to coincide with the period that tree foliage would be present and therefore subject to deposition of lead. The two TRS stations and the GSCA station are represented.

Figure 3:



The six lead-in-dustfall stations in continuous operation between 1981 and 1990 were considered in preparation of Figure 4. As with the suspended particulate lead, only the summer (June through September) data were used. The summer lead-in-dustfall averages for the four stations closest to the TRS property (Nos. 31050, 31055, 31074 & 31085) were averaged to produce the column series labelled 'TRS (A)'. Similarly, data from the two more distant stations (Nos. 31054 & 31056) were averaged to produce the column series labelled 'TRS (B)'. Finally, the summer month averages from the GSCA station are represented in the third column series.

Figure 4:



The most notable features in Figures 3 and 4 are the dramatically lower suspended particulate and dustfall lead levels in 1988, 1989 and 1990. This decline is most apparent at stations located close to the TRS property. The GSCA station also saw declining suspended particulate and dustfall lead levels in the late 1980s. This decline appears more gradual and is attributable to the phase-out of leaded gasoline.

These figures also reveal similarities in the magnitude of ambient air lead levels between the GSCA and the more distant TRS stations. While this report is not intended to interpret the air quality data, it is apparent that TRS had a limited geographic influence.

7 LEAD IN TREE FOLIAGE AND AIR QUALITY MEASUREMENTS

A comparison of the lead concentrations detected in tree foliage with lead measured in suspended particulates and dustfall must be prefaced with certain caveats. The foremost is a reminder that the air quality monitors are not co-located with the tree foliage sites.

Another consideration is the nature of the three monitor types and their capabilities to intercept and retain contaminants. Suspended particulate samplers collect particles that are suspended in an air mass. Dustfall collectors capture larger particles that settle, under gravitational forces, close to their source of origin. Tree foliage would intercept particles that impact on their surfaces. Elements in these particulates would be partially absorbed by the leaf tissue, although rain could wash off some of these particles or leach out some of the previously absorbed substances.

In spite of these restrictions to making direct comparisons between air quality and foliar lead measurements, a comparison of Figure 2 with Figures 3 and 4 reveals that foliar lead concentrations and ambient air lead levels in 1989 and 1990 were only a fraction of those found prior to 1988. Clearly, the closure of the TRS operation has resulted in substantially lower foliar lead concentrations as well as lower ambient air levels. The relative magnitudes of these reductions depend on the location of observation. The greatest reductions occur close to the TRS property. The phase-out of leaded gasoline has also contributed to reduced lead levels in all monitored media. The effect of this phase-out is clearest at the GSCA monitoring locations because the observations are not influenced by a point source.

However, a closer scrutiny of Table 1 reveals foliar lead concentrations at some TRS sites that are not yet at the background concentrations represented by the GSCA sites. In 1990, there were three TRS sites, Nos. 50, 43 and 36, with foliar lead concentrations ranging from 20 to 55 ug/g. The range at the remaining eight TRS sites was from 1.7 to 10 ug/g. The GSCA mean was 4.1 ug/g. In Figure 1, these three sites are shown to be at or near the southern boundary of the TRS property. These sites are within the embankment between the TRS property and the railway tracks.

The Phytotoxicology Section sampled soil along this embankment in December, 1987. Lead concentrations in the surface (0-5 cm) soil ranged from 3,900 to 90,000 ug/g (Ref. 3). During the 1989 and 1990 foliage sampling, which occurred after the soil replacement program, there was no visual evidence that this severely contaminated soil had been replaced. Although maps in the consulting engineer's report (Ref. 2) show this embankment as part of Block D of the soil replacement zone, the soil was not replaced because it was not considered a publicly accessible site. Consequently, the marginally elevated foliar lead at these sites can be attributed to uptake by tree roots. Although lead is not readily taken up by plants, at soil concentrations of this magnitude, some uptake would reasonably be expected.

The alternate source of these marginally elevated foliar lead concentrations might be re-entrainment of contaminated dust or soil from the TRS property. However, the air quality measurements indicate that lead in suspended particulates and dustfall near TRS are at the background levels currently encountered at the GSCA. (See Figures 3 and 4.)

8 CADMIUM, ANTIMONY AND ARSENIC IN TREE FOLIAGE

As was reported in Section 4.2, cadmium, arsenic and antimony in tree foliage were typically below analytical detection or accurate quantification. The exception was foliage at Site 36, with detectable cadmium. Coincidentally, Site 36 is on the railway embankment where surface soil lead concentrations were 90,000 ug/g. The soil samples collected in December, 1987 were also analyzed for cadmium, arsenic and antimony. These data have not previously been reported. Cadmium concentrations in the top five

centimetres ranged from 380 to 480 ug/g at Site 36. A single sample from the 15 to 20 centimetre depth had 21 ug/g Cd. Site 36 was the most contaminated site for cadmium along the embankment. It appears that the tree foliage at Site 36 is reflecting the very high soil cadmium concentrations through root uptake. Cadmium is ranked as the most readily accumulated metal by green plants from soil (Ref. 4).

Soil concentrations of arsenic and antimony were also extremely high along this embankment, with concentrations ranging up to 3,000 and 1,500 ug/g, respectively. However, since plants do not readily take up these elements, foliar concentrations do not reflect the soil conditions. Arsenic and antimony are ranked lower than lead for accumulation by plants (Ref. 4).

9 SUMMARY AND CONCLUSIONS

In 1989 and 1990 the Phytotoxicology Section collected tree foliage samples from Ailanthus trees at 11 sites in the vicinity of the former Toronto Refiners and Smelters (TRS) operation. Ailanthus foliage was also collected in the Gerrard Street Control Area (GSCA). These samples were analyzed for lead and other contaminants. The data revealed dramatically lower lead concentrations in the TRS samples compared to those collected in 1987 and previously. This decline is directly attributable to the closure of the TRS operation. Lead concentrations in tree foliage from the GSCA also declined substantially, reflecting the discontinued use of lead in gasoline.

A review of lead air quality data collected at stations near TRS and in the GSCA corroborated the trends in the foliar concentrations.

The average lead in tree foliage concentrations near the TRS property are approaching those present in the GSCA. However, certain TRS sites retain marginally-elevated foliar lead concentrations. This contamination is attributable to root uptake from soil which has extremely high lead concentrations and has not been remediated. Severe cadmium contamination of soil at one site is also reflected in marginally elevated foliar cadmium concentrations.

10 REFERENCES

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11. Appendix

Derivation and Significance of the MOEE Phytotoxicology "Upper Limits of Normal" Contaminant Guidelines.

The MOEE Upper Limits of Normal (ULN) contaminant guidelines represent the expected maximum concentration in surface soil, foliage (trees and shrubs), grass, moss bags, and snow from areas in Ontario not exposed to the influence of a pollution source. Urban ULN guidelines are based on samples collected from urban centres, whereas rural ULN guidelines were developed from non-urbanized areas. Samples were collected by Phytotoxicology staff using standard sampling procedures (reference: *Ontario Ministry of the Environment. 1989. Ontario Ministry of the Environment "Upper Limit of Normal" Contaminant Guidelines for Phytotoxicology Samples. Phytotoxicology Section, Air Resources Branch: Technical Support Sections NE and NW Regions, Report No. ARB-138-88-Phyto. ISBN: 0-7729-5143-8.*). Chemical analyses were conducted by the MOEE Laboratory Services Branch.

The ULN is the arithmetic mean plus three standard deviations of the suitable background data for each chemical element and parameter. This represents 99% of the sample population. This means that for every 100 samples that have not been exposed to a pollution source, 99 will fall within the ULN.

The ULNs do not represent maximum desirable or allowable limits. Rather, they are an indication that concentrations that exceed the ULN may be the result of contamination from a pollution source. Concentrations that exceed the ULNs are not necessarily toxic to plants, animals, or people. Concentrations that are below the ULNs are not known to be toxic.

ULNs are not available for all elements. This is because some elements have a very large range in the natural environment and the ULN, calculated as the mean plus three standard deviations, would be unrealistically high. Also, for some elements, insufficient background data is available to confidently calculate ULNs. The MOEE Phytotoxicology ULNs are constantly being reviewed as the background environmental data base is expanded. This will result in more ULNs being established and may amend existing ULNs.

